Roy Fritz

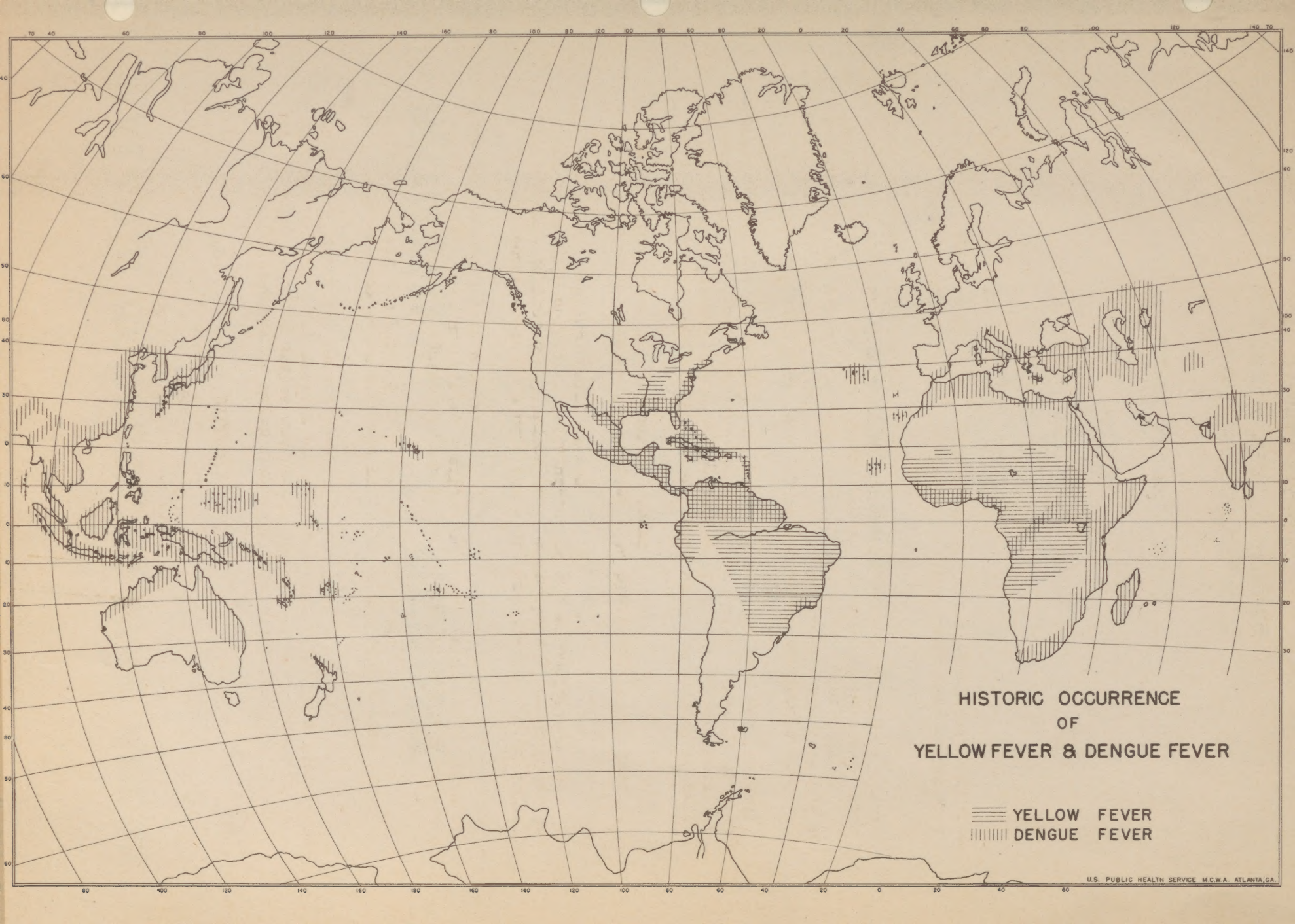
# MALARIA CONTROL IN WAR AREAS

# MONTHLY REPORT

## MARCH, 1943

AEDES AEGYPTI ISSUE

FEDERAL SECURITY AGENCY
U. S. PUBLIC HEALTH SERVICE
ATLANTA, GEORGIA


HISTORIC OCCURRENCE
OF
YELLOW FEVER & DENGUE FEVER
YELLOW FEVER
DENGUE FEVER
U.S. PUBLIC HEALTH SERVICE M.C.W.A. ATLANTA, GA.

MONTHLY REPORT
Malaria Control in War Areas
March, 1943

SYLLABUS

Warmer weather in March increased anopheline breeding in some of the more southern states and necessitated a limited amount of larvicidal control. Dry weather and drainage made possible a further reduction of larvicidal activities in Puerto Rico.

Twelve new major drainage projects in six states were begun this month and one project in Texas was completed.

Transfers of equipment from other Government Agencies included small tools, movie materials, drafting supplies, surveying instruments, one dragline and four trucks.

Two conferences were held for state and District entomologists. The conferences included instruction in entomological techniques, lectures on malaria control and discussion of the entomological work for the past year and the coming season.

A summary to date of the thick film blood survey for 1942 is given in this issue of the Monthly Report.

There have been no new appointments nor replacements of personnel since the "freeze order" effective March 25, 1943. Projects for the protection of new War establishments have been unable to start operating and work in several established areas has been handicapped.

A new dengue-yellow fever control program was inaugurated at Savannah, Georgia this month. In Texas, a small unit was detailed to San Antonio for survey work and the elimination of Aedes aegypti "mother foci"; another unit is conducting a survey of Beaumont, Port Arthur and Orange. Low breeding indices were reported from all control projects, both new and old.

About $588,000 of Public Health Service funds were encumbered in March. Approximately 83% of this amount was for personal services.

TABLE I

MALARIA CONTROL IN WAR AREAS

USPHS LARVICIDE AND MINOR DRAINAGE PROJECTS

MARCH 1 - 31, 1943

| STATE | Areas in Operation | War Establishments Protected | LARVICIDAL WORK | | | OTHER WORK | | | Total Man Hours | Total Men Employed |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Larvicide Used | | Surfaces Treated | Ditching & Cleaning Lin.Ft. | Clearing | | | |
| | | | Oil Gals. | Paris Green Lbs. | Acres | | Ditches Lin.Ft. | Ponds Acres | | |
| Alabama | 5 | 25 | --- | --- | --- | 44,982 | 5,000 | 0.6 | 11,107 | 62 |
| Arkansas | 11 | 36 | --- | --- | --- | 72,665 | 3,275 | 125.5 | 25,520 | 144 |
| California | 3 | 4 | 4,329 | --- | 421.0 | 14,608 | --- | 8.0 | 5,480 | 30 |
| D. C. | 1 | 17 | --- | --- | --- | 8,448 | 4,071 | --- | 4,240 | 23 |
| Florida | 10 | 58 | 146 | 49 | 50.5 | 258,130 | 104,551 | 5.5 | 35,836 | 178 |
| Georgia | 10 | 57 | --- | 100 | 80.0 | 42,795 | 92,365 | 47.7 | 23,584 | 121 |
| Indiana | 1 | 4 | --- | --- | --- | 1,550 | --- | 0.7 | 2,268 | 10 |
| Illinois | 1 | 10 | --- | --- | --- | --- | --- | --- | 488 | 4 |
| Kentucky | 3 | 16 | --- | --- | --- | 35,040 | --- | 7.5 | 4,254 | 40 |
| Louisiana | 8 | 42 | 13,075 | 205 | 1,025.8 | 487,462 | 155,055 | 609.4 | 78,495 | 442 |
| Maryland | 2 | 7 | --- | --- | --- | 17,641 | --- | 0.8 | 4,576 | 24 |
| Mississippi | 7 | 9 | --- | --- | --- | 132,567 | 13,473 | 32.9 | 16,250 | 98 |
| Missouri | 2 | 14 | --- | --- | --- | 3,300 | 125 | 2.4 | 1,937 | 12 |
| North Carolina | 10 | 48 | --- | --- | --- | 295,023 | 5,700 | 40.4 | 33,570 | 180 |
| Oklahoma | 4 | 10 | --- | --- | --- | 12,900 | 15,280 | 22.4 | 4,446 | 27 |
| Puerto Rico | 7 | 17 | 425 | 5,298 | 4,282.3 | 316,370 | 39,555 | 22.8 | 64,891 | 388 |
| Tennessee | 6 | 40 | --- | --- | --- | 33,138 | 18,735 | 29.0 | 9,870 | 55 |
| Texas | 14 | 153 | 6,199 | --- | 281.9 | 330,370 | 93,607 | 84.2 | 43,186 | 246 |
| Virginia | 4 | 21 | --- | --- | --- | 165,269 | 630,512 | 13.5 | 26,662 | 158 |
| Total | 109 | 588 | 24,174 | 5,652 | 6,141.5 | 2,272,258 | 1,181,304 | 1,053.3 | 396,660 | 2,242 |
| February Total | 102 | 621 | 22,522 | 6,222 | 3,991.9 | 2,021,791 | 1,463,548 | 416.1 | 357,963 | 2,193 |
| Total July 1 - March 31 | --- | --- | 1,439,608 | 94,895 | 133,794.6 | 18,121,110 | 25,397,154 | 7,690.1 | 3,645,227 | --- |

TABLE II

MALARIA CONTROL IN WAR AREAS

USPHS MAJOR DRAINAGE PROJECTS

MARCH 1 - 31, 1943

| STATE | No. of Projects | Clearing Brushing Acres | Channel or Ditch Cleaning Lin. Ft. | New Ditching | | Fill Cu.Yds. | Ditch Lining | | Underground Drains Lin.Ft. | Water Surf. Eliminated Acres | Total Man Hours |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Lin.Ft. | Cu.Yds. | | Sq.Ft. | Lin.Ft. | | | |
| Arkansas | 2 | 21.2 | 10,945 | 5,100 | --- | --- | --- | | --- | --- | 5,098 |
| Florida | 1 | 12.5 | --- | --- | --- | --- | --- | | --- | --- | 9,338 |
| Illinois | 2 | --- | 1,200 | 2,740 | 793 | --- | --- | | --- | 6.9 | 2,227 |
| Kentucky | 3 | 6.5 | 3,400 | 8,350 | 1,039 | 46 | --- | | --- | 4.0 | 5,252 |
| Mississippi | 4 | 0.9 | 1,800 | 9,946 | 1,442 | 2,293 | --- | | --- | 16.7 | 9,713 |
| Missouri | 2 | --- | --- | --- | --- | 20 | --- | | --- | --- | 493 |
| North Carolina | 4 | 16.9 | 30,429 | 16,369 | 8,667 | 2,325 | --- | | --- | 83.0 | 25,042 |
| Oklahoma | 3 | --- | --- | 5,467 | 1,071 | 138 | --- | | --- | 17.0 | 3,854 |
| Puerto Rico | 2 | 9.3 | 1,450 | 1,800 | 6,075 | --- | --- | | --- | --- | 52,192 |
| South Carolina | 19 | 33.2 | 87,693 | 38,554 | 21,920 | 10,444 | --- | | --- | 108.2 | 93,517 |
| Tennessee | 3 | 10.1 | 1,900 | 13,773 | 1,995 | --- | --- | | --- | 16.0 | 5,867 |
| Texas | 8 | 2.2 | 8,570 | 13,095 | 4,125 | 246 | --- | | --- | 3.0 | 9,503 |
| Virginia | 3 | 5.1 | 13,090 | 1,722 | 192 | --- | --- | | --- | --- | 3,370 |
| Total | 56 | 177.9 | 160,477 | 116,916 | 47,319 | 15,512 | --- | | --- | 254.8 | 225,466 |
| February Total | 50 | 157.7 | 182,892 | 90,601 | 49,957 | 13,595 | --- | | --- | 214.2 | 169,097 |
| Total July 1 - March 31 | -- | 924.4 | 1,370,646 | 453,725 | 298,110 | 49,648 | --- | | --- | 1,184.5 | 848,429 |

TABLE III

MALARIA CONTROL IN WAR AREAS

NUMBER OF PERSONNEL ON DUTY ON MARCH 31, 1943 AND TOTAL PAYROLL FOR MONTH OF MARCH

| STATE | TYPE OF PERSONNEL | | | | | | | | | | | | Percent of Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Commissioned | | Prof. & Sci. | | Sub-Prof. (1) | | C. A. F. | | Custodial | | Total | | | |
| | No. | Pay | No. | Pay | No. | Pay | No. | Pay | No. | Pay | No. | Pay | No. | Pay |
| Alabama | 1 | 285 | 5 | 1,318 | 2 | 347 | 2 | 410 | 58 | 6,903 | 68 | 9,263 | 1.7 | 1.9 |
| Arkansas | 5 | 1,265 | 2 | 633 | 22 | 4,351 | 4 | 702 | 157 | 19,534 | 190 | 26,485 | 4.8 | 5.4 |
| California | -- | --- | 1 | 203 | 3 | 868 | 2 | 440 | 26 | 3,897 | 32 | 5,438 | 0.8 | 1.1 |
| D. C. | 2 | 652 | 2 | 406 | 2 | 549 | 3 | 570 | 17 | 1,914 | 26 | 4,091 | 0.7 | 0.8 |
| Florida | 2 | 533 | 8 | 1,429 | 14 | 3,355 | 4 | 750 | 240 | 28,619 | 268 | 34,686 | 6.7 | 7.1 |
| Georgia | 1 | 285 | 4 | 872 | 26 | 4,964 | 6 | 882 | 99 | 12,154 | 136 | 19,157 | 3.4 | 3.9 |
| Illinois | 2 | 618 | 3 | 651 | 4 | 706 | 1 | 133 | 7 | 1,144 | 17 | 3,252 | 0.4 | 0.7 |
| Indiana | 1 | 285 | 1 | 240 | -- | --- | 1 | 133 | 11 | 1,399 | 14 | 2,057 | 0.4 | 0.4 |
| Kentucky | 1 | 285 | 4 | 1,049 | 10 | 1,265 | 3 | 532 | 61 | 6,588 | 79 | 9,719 | 2.0 | 2.0 |
| Louisiana | 8 | 2,318 | 6 | 1,329 | 43 | 7,812 | 5 | 965 | 428 | 52,872 | 490 | 65,296 | 12.3 | 13.4 |
| Maryland | -- | --- | -- | --- | 4 | 677 | 2 | 410 | 11 | 2,704 | 17 | 3,791 | 0.4 | 0.8 |
| Mississippi | 2 | 618 | 2 | 527 | 12 | 2,646 | 2 | 410 | 138 | 16,277 | 156 | 20,478 | 3.9 | 4.2 |
| Missouri | 2 | 618 | 4 | 887 | 9 | 1,626 | 1 | 152 | 10 | 1,415 | 26 | 4,698 | 0.7 | 0.9 |
| North Carolina | 3 | 855 | 9 | 2,345 | 10 | 1,973 | 3 | 556 | 323 | 37,465 | 348 | 43,194 | 8.7 | 8.9 |
| Oklahoma | 1 | 285 | 3 | 925 | 5 | 1,024 | 1 | 146 | 43 | 5,425 | 53 | 7,805 | 1.3 | 1.6 |
| Puerto Rico | 5 | * | 1 | * | 8 | * | 6 | * | 602 | * | 622 | 30,580 | 15.6 | 6.3 |
| South Carolina | 3 | 867 | 6 | 1,505 | 26 | 5,618 | 3 | 592 | 510 | 60,425 | 548 | 69,007 | 13.8 | 14.1 |
| Tennessee | 3 | 855 | 2 | 527 | 6 | 1,392 | 1 | 297 | 89 | 9,852 | 101 | 12,903 | 2.5 | 2.6 |
| Texas | 3 | 855 | 7 | 2,062 | 30 | 6,025 | 4 | 720 | 280 | 34,034 | 324 | 43,696 | 8.1 | 8.9 |
| Virginia | 2 | 570 | 2 | 688 | 8 | 1,598 | 2 | 428 | 191 | 21,364 | 205 | 24,648 | 5.1 | 5.1 |
| *Aedes aegypti* | | | | | | | | | | | | | | |
| Florida | -- | --- | 1 | 319 | 42 | 4,983 | 3 | 456 | 27 | 3,686 | 73 | 9,444 | 1.8 | 1.9 |
| Georgia | -- | --- | -- | --- | 3 | 174 | -- | --- | -- | --- | 3 | 174 | 0.2 | 0.3 |
| Louisiana | -- | --- | -- | --- | -- | --- | 1 | 44 | -- | --- | 1 | 44 | 0.1 | 0.1 |
| South Carolina | 1 | 285 | -- | --- | 12 | 1,982 | 1 | 146 | 5 | 702 | 19 | 3,115 | 0.5 | 0.6 |
| Texas | 1 | 285 | 4 | 788 | 10 | 2,271 | 1 | 146 | 8 | 944 | 24 | 4,434 | 0.6 | 0.9 |
| H.Q. & Dist. (2) | 34 | 11,022 | 12 | 2,689 | 19 | 4,355 | 69 | 11,185 | 6 | 674 | 140 | 29,925 | 3.5 | 6.1 |
| Total | 83 | 23,641 | 89 | 21,392 | 330 | 60,591 | 131 | 21,205 | 3,347 | 329,971 | 3,980 | 487,380 | 100.0 | 100.0 |
| Percent of Total | 2.1 | 5.2 | 2.2 | 4.7 | 8.3 | 13.3 | 3.3 | 4.6 | 84.1 | 72.2 | 100.0 | 100.0 | | |

* Figures not available

(1) Includes Entomological Inspectors

(2) Includes Headquarters and District offices, malaria survey, special investigations and employees temporarily attached to Headquarters pending assignment to States.

MONTHLY REPORT
Malaria Control in War Areas
March, 1943

The advent of warmer weather in March produced an increase in anopheline breeding in the more southern states. Limited larvicidal operations were conducted in California, Florida, Georgia, Louisiana and Texas. Larvicidal work in Puerto Rico continued to decline during the month as a result of drier weather and effective drainage in certain areas. Progress of the larvicide and minor drainage work is presented in Table I.

Major Drainage - Twelve new major drainage projects were started this month in Texas, Virginia, Tennessee, Florida, Oklahoma and North Carolina. One project at Texarkana, Texas was completed. Data on the major drainage program for March are shown in Table II.

Equipment - A large amount of equipment including small tools, movie materials, drafting supplies, surveying instruments and one 1 1/4 cubic yard dragline was secured through transfer from the Work Projects Administration. Four trucks were also transferred to MCWA in March and it is expected that 10 to 15 more truck transfers will be approved in April. A shortage of automotive equipment still exists, but if all transfers are approved, it will be generally possible to meet the absolute minimum requirements for the coming season. Automotive equipment now in use on Malaria Control in War Areas projects includes: 361 trucks, 46 station wagons, 103 sedans, 4 two-wheel trailers and 1 tractor.

Maps - Six field checked maps were received from the states and tracings were completed in this office. Nineteen maps were sent to the field for checking during the month. Seven more are essentially complete except for final checking and will be sent to the field soon; fifteen other maps are in various stages of completion.

Entomology - Two conferences were held at the U. S. Bureau of Entomology and Plant Quarantine Laboratory, New Smyrna Beach, Florida, for state and District entomologists. Instruction was given in mosquito identification and techniques and in MCWA procedures. Lectures were presented on engineering methods in malaria control and on techniques of studying the malaria parasite. Entomological work of the past year and plans for the coming season were discussed. The conferences were attended by 32 persons.

In order to coordinate better the work of District entomologists and engineers, arrangements have been completed to assign the regional entomologists to the District offices in Districts 3, 4 and 7. Regional supervision of entomologists in Districts 2 and 9 will be handled through the Headquarters Office.

Educational Program - Two new movie scripts, "Mosquito Census" and "Larvicide" were begun in March. Several mosquito movies were re-

viewed and descriptions of them prepared and filed for future reference. The movies and film strips being produced by this office are designed for training personnel to meet the immediate demands of the Malaria Control in War Areas program.

Blood Survey - Approximately half the thick film malaria slides collected during the fall and winter of 1942 have been examined. A summary of the results to date of this survey is presented below:

SUMMARY OF SLIDES RECEIVED AND EXAMINED TO MARCH 31, 1943

SLIDES EXAMINED IN MEMPHIS LABORATORY:

| State | No. Slides Received | No. Slides Examined | Number Positives | Percentage Positives |
|---|---|---|---|---|
| Alabama | 5314 | 4482 | 17 | 0.379% |
| Arkansas | 4851 | 4832 | 38 | 0.786% |
| District of Columbia | 1293 | 1293 | 0 | |
| Florida | 11815 | 1716 | | |
| Illinois | 620 | 620 | 0 | |
| Louisiana | 2330 | 1395 | 22 | 1.57% |
| Kentucky | 13130 | 4225 | 7 | 0.163% |
| Maryland | 338 | 338 | 0 | |
| Mississippi | 6140 | 6159 | 19 | 0.308% |
| Missouri | 7743 | 3829 | 3 | 0.078% |
| North Carolina | 13794 | 2633 | 4 | 0.151% |
| Oklahoma | 1901 | 1896 | 4 | 0.211% |
| Tennessee | 2314 | 2375 | 0 | |
| Virginia | 672 | | | |
| Totals | 72255 | 35793 | 114 | 0.318% |

SLIDES EXAMINED IN STATE LABORATORIES:

| | | | | |
|---|---|---|---|---|
| Georgia | 1611 | 1103 | 3 | 0.272% |
| South Carolina | 5981 | 350 | 0 | |
| Texas | 39791 | 24667 | 104 | 0.42% |
| Totals | 47383 | 26120 | 107 | 0.409% |

Personnel and Payroll - Effective March 25, 1943 the "freeze order" prevented new appointments, and personnel discontinued previous to this date has not been replaced. Recruitment of personnel on both commissioned and Civil Service status has been halted. Projects for the protection of new War establishments have been unable to start operating and work in several established areas has been handicapped.

Newly commissioned personnel during the month of March included six entomologists and two engineers. Two Assistant Surgeons were transferred to this program to replace two commissioned medical officers released for other services. In connection with educational and per-

sonnel training activities, two Associate Public Health Educators and one Special Consultant were appointed, two of these being new employees. A summary of data on the number of employees and the payroll by states is given in Table III.

Aedes aegypti Control - Due to conditions arising from the War, control of the Aedes aegypti mosquito has become a significant problem. Beginning in July, 1942, the MCWA program inaugurated Aedes aegypti surveys in some of the Gulf Coastal cities. These projects will be maintained in 1943 and control will be extended to other important War centers. It was considered desirable at this time to present a broad picture of the Aedes aegypti problem. This issue of the Monthly Report features the control of this mosquito and a brief discussion of the two diseases carried by it. (The "quad" on the front cover was replaced this month by an Aedes aegypti.)

A new dengue-yellow fever control unit was inaugurated at Savannah, Georgia with headquarters in the Henry Rose Carter Memorial Laboratory. The project is being operated in close cooperation with the City and State Health Offices. The primary function of this unit is to establish the density of aegypti in Savannah and to accomplish as much incidental control as is possible with the small crew of ten men. It is planned to depend largely on educational procedures and cooperation of householders to accomplish control, as has been done in Texas.

A small unit has been detailed to San Antonio, Texas for survey work and the elimination of "mother foci". In addition, another small unit is conducting a survey of Beaumont, Port Arthur and Orange, Texas. The project in Hidalgo County, Texas, which was suspended during the winter, was re-established this month.

The indices of aegypti breeding, at both old and new projects, were exceptionally low in March. This condition would have been expected at the more northerly points even without control; however, at Miami and Key West, Florida, where breeding would normally continue with little abatement throughout the winter, the low indices of 1.4% and 1.18% respectively are significant, particularly at Key West where the index represents a complete inspection of the interior and exterior of every premise in the entire city.

Expenditures - About $588,000 of Public Health Service funds were encumbered during March. The approximate amounts were as follows:

| | |
|---|---|
| .01 Personal Services | $487,380 |
| .02 Travel | 14,990 |
| .03 Transportation | 7,820 |
| .04 Communication Services | 12,000 |
| .05 Rent | 1,520 |
| .06 Printing and Binding | 680 |
| .07 Other Contractual Services | 4,420 |
| .08 Supplies and Materials | 28,090 |
| .09 Equipment | 30,980 |
| Total | $587,880 |

## THE AEDES AEGYPTI PROGRAM

Aedes aegypti, the mosquito which is primarily responsible for the transmission of yellow fever and dengue, has followed man completely around the world in the tropics and sub-tropics on every continent. Its closest relatives in the subgenus Stegomyia are tree-hole breeders in Africa. Somewhere in its past history it developed two habits that have become as fixed in its genetic constitution as the silvery, lyre-like markings of its thorax and the snowy white bands of its legs. These are (1) a close association with man (breeding never occurs at any great distance from man's habitations) and (2) the predilection for artificial water containers for breeding purposes, at least for those members of the species that have migrated away from Africa.

Its ancestral habit of breeding in tree-holes is emphasized by its preference for wooden containers, then earthenware or cement ones and finally, metal. Apparently this habit is controlled by its oviposition procedure as its eggs are laid on the surface of the water at the waterline or just above the waterline on the sides of the container. Thus the sides of the container exercise more influence than the bottoms which may be as clean as the sides or covered with sedimented mud or debris. However the contained water does influence the choice, as clear, although not necessarily clean, water is preferred.

The fact that yellow fever is ordinarily confined to the tropics and sub-tropics is because its principle carrier, Aedes aegypti, flourishes only in the presence of relatively high temperatures. The eggs and larval forms (wrigglers) can survive considerable cold weather, even short exposures to freezing temperatures. However, continued cold weather, (50°-68°F. nightly for 70 days) destroys 95 per cent of exposed eggs.' Although we have no experimental evidence available, observation suggests that prolonged cold, even when well above freezing, produces considerable mortality among larvae. Adults feed, breed and oviposit with great facility at temperatures between 80° and 87°F. As the temperatures decrease oviposition is the first function to fail, feeding ceases at slightly above 60°F., activity ceases at 50°F. and death is produced by twenty-four hours exposure to temperatures of 42°F. and almost immediately below 32°F. Hence the rejoicing with which the first frosts were greeted in epidemic years in our stricken cities when the virus of yellow fever was a frequent visitor to our shores, or in recent years when the dengue virus was rampant in some of our southern communities.

This resume of temperature requirements immediately raises the question of aegypti survival in the United States. The only frost free city in the country is Key West. Hence it should be the only city of continuous breeding with adult females available at all times of the year. This is probably true over a period of years although other cities may have occasional years when no frosts occur. However, yellow fever has been epidemic as far north as Ohio and New England and even Quebec, and the usual explanation has been that the mosquito vector was reintroduced each year during the hot summer months when conditions were favorable for its propagation. This is probably true for the more northerly areas of its recorded distribution. However in the border line area represented by the deep South where some stages of the mosquito can be demonstrated in nearly every month of the year, other explanations will doubtless be forthcoming. The mosquito-lore of aegypti has been written in the tropics and is voluminous, but little is known of its vagaries in southern United States or in its extensions into the arid West (as far as Tucson, Arizona) or to the northern limits of its known distribution.

Carter reported an observation of Mr. Le Prince at Carbondale, Illinois where he observed reproduction and feeding of aegypti on January 19th and March 20th in a hotel where breeding was flourishing in a container for flower pots. If this were general, it would be easy to account for the relatively rapid build-up of the species when warm weather returns; but in our, as yet rather limited, experience in connection with the present aegypti program, we have been struck by the paucity of inside breeding during the winter months. At Savannah, Georgia where no organized control work was performed last summer, the initial inspections made in late March and early April showed a very small percentage of breeding, less than two per cent of the premises visited, with about two inside breeders to one outside. However most of the so-called "inside breeders" were fire barrels, troughs and relatively large containers in semi-public buildings and not the domestic type of water plant, flower-vase breeder that we ordinarily picture as the typical inside breeder.

More information may change the picture radically but from the information at hand it would seem that aegypti winters-over in the southern portion of the frost belt as a slowly maturing larva in relatively large containers of water in protected places. In addition, a number of eggs deposited in the fall before the females were killed by cold weather probably still remain viable and await the advent of water in the containers where they were deposited and warm weather to speed their development. In the more northerly portions of its range (north of Norfolk, Virginia) it must depend on inside breeding in unusually well heated buildings or passive reintroduction from the south as eggs on containers, as larvae on riverboats or coastwise ships or as adults in trains, automobiles, or air-·

planes. Other factors than temperature undoubtedly restrict its distribution in the Southwest and up the Pacific Coast. Apparently low humidity and the absence of summer rains is a controlling influence.

## Control

There are two main schools of thought in aegypti control with many variations of each, all of which are predicated on tropical conditions. Both agree that the only solution to the aegypti problem is eradication, the practicability of which has been demonstrated in the principal cities of Brazil. One school believes however that the only method of accomplishing elimination is by a concerted, simultaneous attack on every possible type of breeding place in the community from roof gutters to cellar sumps. The other group would first concentrate on the "mother foci" searching out every permanent container such as cisterns, shallow wells, fire barrels, sumps, and similar situations which hold water year in and year out. They would ignore such breeders as roof gutters which will eventually be flushed out by storms, tin cans which will rust out, flower vases which will be emptied and other temporary breeding places, until the concentrated attack on mother foci has been accomplished. They believe that as the mother foci are eliminated, "seed" for the non-permanent places will be cut off and the incidental breeding in the tin cans and flower vases will decrease in direct proportion to the elimination of the mother foci. In fact, the continued breeding in an area in vases, cans and similar containers is considered to be an indication that a mother focus in that immediate area is still existant. Our observations to date are wholly in accord with this latter procedure as a routine, efficient manner of approach. Under epidemic conditions where the quickest possible elimination or reduction of adult females is the ultimate goal and expense and man power are of secondary importance, naturally the all-out, shotgun procedure is the only one to adopt.

When it is considered that the adult female aegypti seldom flies on her own power more than 75-100 yards from the container in which she lived as a larva, it becomes apparent at once that practically everyone breeds his own household supply. Control is an individual problem or at least a community problem that can be solved by individual effort without the need for group action, or finance, or expensive equipment.

For this reason it is a problem in community service in which education can be translated into action by any able bodied man, woman or child without the necessity of awaiting group action, legislation, financial support or anything other than the desire and the expenditure of a few minutes of time to do their part in making their community a safer and healthier place in which to live.

In the Texas, South Carolina and Georgia projects, we have consequently placed a great deal of emphasis on the educational phases of the program rationalizing that it was the democratic approach which would educate the public to its responsibilities but tinged, perhaps, by the knowledge that we lacked the man power and funds to inaugurate a paternalistic campaign in which governmental employees would do the necessary work much faster and more efficiently and thoroughly.

The results of this educational work, supplemented by expert inspection and the incidental correction that accompanies the inspections has been surprisingly gratifying. In Houston, for instance, in a city of 450,000 people our paid inspectional staff consisted of only six inspectors. If we had operated there as we did in Key West with the inspection of each premise both outside and inside on a schedule approaching a complete inspection of the city each week and with all the incidental special services of an epidemic campaign, it would have required 800 employees. By interesting the school children, luncheon clubs, firemen and other organizations and by continual news releases, radio and movie contacts, the index of premises breeding aegypti was held at a figure consistently below the 5 per cent that has been empirically established as the percentage below which epidemic yellow fever or dengue is not possible. All of our other projects in Texas - at Galveston, Corpus Christi, Brownsville, San Antonio and Hidalgo County - are being conducted on this basis with major emphasis on education and public cooperation through individual effort augmented by the efforts of an otherwise entirely inadequate staff of inspectors.

In Florida, the Key West project is being carried on with all the services that would be inaugurated in the time of an epidemic. Inspectors visit each room of every dwelling and business establishment in the city approximately once a week; every potential mother focus in the city is numbered and visited once a week for appropriate treatment; all roof gutters are inspected and cleaned at least once a month; all boats in the harbor are inspected at weekly intervals; vacant lots overgrown with vegetation are cleaned in the search for breeding containers or hidden wells or cisterns; tin cans are methodically collected; and the discovery of inside breeding is followed immediately by an aerosol spraying of the premises. When the project was started in June 1942, the index of breeding was 38 per cent of the properties inspected. Looking back on this original survey, the men who made it are confident that if they had known the city as well then as they do now that the index would have been well over 50 per cent. By late summer when breeding should have been high, the index had fallen to less

than 3 per cent and now (March 1943) it hovers around 1 per cent with few if any adults escaping to perpetuate the race. It is confidently anticipated that it can be announced by late summer that aegypti mosquitoes have been eliminated from Key West. If such is the case, it will be the first instance of aegypti elimination by control methods from a North American city.

Miami, Miami Beach, and some of the surrounding county territory are critical areas from the quarantine standpoint on account of the key air fields in the vicinity. Before the War the Public Health Service had been supplementing the appropriations of the Dade County Anti-mosquito District through Title VI funds which had been allocated through the State Health Department to aid in the control of aegypti mosquitoes. With the inauguration of aegypti control by the MCWA program, the financial and administrative responsibility for the Miami district was assumed by the MCWA office working through the Florida State Board of Health as in the case of Key West. The staff was augmented and the director of the Dade County district was asked to direct the local work.

The inspection and correction program was limited to outside premises except in the case of establishments open to the public. On this basis the breeding index for the calendar year of 1942 was 4.4 per cent for the entire area. From our experience in other cities it is probable that this figure could have been nearly doubled if interior inspections in the residential areas had been included. This index is too high for safety, but the encouraging note is that the index for five special areas including four important air fields and their surrounding communities and the exceedingly extensive military establishments which were inspected both inside and out showed an index of only 1.07 per cent.

Charleston, too, had been receiving Title VI funds through the South Carolina State Board of Health to aid in the control of aegypti mosquitoes. In August of 1942 this project was included in our program and an entomologist assigned from this office to direct the local inspection staff. For the period August 1 to November 30 the index for outside inspections only was 2.5 per cent. From December first to date (March 31, 1943), the index has been consistently below 1 per cent, reflecting the fact that Charleston is near the northern limit of the natural range of the species. A little work at Charleston pays surprisingly large dividends. Careful inspection under skilled direction such as we have at present may very well produce elimination at this point even though our inspectional staff of 15 men is probably much too small to cover adequately as large a city as Charleston.

This month (March 1943) we inaugurated a survey and incidental correction program at Savannah with headquarters at the Henry Rose Carter Memorial Laboratory. Conditions here are more difficult of control than at Charleston because of the lack of previous work and the increased biological problem incident to its location. Winter breeding is apparently present in Savannah with approximately twice as much interior breeding as exterior.

At both Charleston and Savannah, an organized educational effort is being developed in the school system utilizing the program of the Victory Corps curricula. The aegypti campaign lends itself particularly well to this program as there is an almost perfect opportunity for education to be translated into constructive action. The effort is being watched with interest as an experiment in the utilization and training of students in intelligent participation in community health programs.

During April a small group of inspectors (20) will inaugurate a survey of New Orleans, historic gateway of yellow fever into the United States. Funds for this work will terminate at the end of the present fiscal year but it is hoped that by that time we will have been able to establish an accurate estimate of the density, the principal points at which work should be concentrated in time of emergency and possibly have caused some reduction by the control incidental to inspection and the educational phases that always accompany such an undertaking.

Through the operation of this program we will have demonstrated in a number of representative municipalities the possibility of achieving effective control and possibly even of eliminating this species. In every case, except Key West, we have done the work on a financial scale that is well within the possibilities for continuation by the municipality.

It can easily be seen from the above that the MCWA program, which is designed to protect only War projects, cannot assume the responsibility for protecting continental United States from the appearance of yellow fever or dengue by eliminating aegypti mosquitoes or reducing them at all possible points where the viruses may be introduced to a point below the "threshold of sanitary importance". In fact, the mathematical chances are that when, and if, either of these diseases does become epidemic it will be at some point where we have not worked. But we have a trained personnel with full working equipment capable of being marshalled at any point in the Southern States within twenty-four hours after either of these diseases is located. Working out in expanding circles from centers of infection there is no reason why there should be an aegypti mosquito left within seven blocks of the focus at

the end of the first day's work.

The possibilities of this unit, along with medical precautions such as vaccination, early diagnosis and adequate care of the sick, and an educational campaign to advise the lay public of the necessary precautions, leads us to believe that any outbreak of yellow fever or dengue would be brought under control quickly and efficiently.

## DENGUE FEVER

The origin of the name is as confused as the multiplicity of pronunciations which range from den -gu to deng´- gay to what is perhaps the most common in this country, - deng-gy. One of the most plausible explanations is that it comes from the Spanish word danguero which means fop or dandy and was applied because of the stiff backed gait common to both sufferers from the disease and the Beau Brummells of the period. In fact, one of the commonest names for the disease is "dandy fever" which lends credence to the story of its derivation. Others are "break-bone fever" applied by Rush, three-day, six-day or seven-day fevers, the last three of which are by no means confined to dengue alone.

In the light of the present day distribution of dengue it is interesting to note that one of the first good descriptions of the disease was written by Benjamin Rush shortly after the Revolution during an epidemic in Philadelphia, which serves to remind us that dengue, like yellow fever, has penetrated as far within this country as New York and Boston on several occasions.

In fact, dengue completely encircles the world following the distribution of Aedes aegypti and Aedes albopictus. Unlike yellow fever however, it has penetrated to South Asia, Australia and the Pacific islands and occurs in endemic form at various spots around the Mediterranean and sporadically throughout the entire basin. In the United States it occurs sporadically along the South Atlantic Coast, the Gulf Coast and up the Rio Grande Valley. Its appearance is sudden, apparently without any long time build up from previous seasons and generally devastating in its results. Serious epidemics involving from 25 to 75 per cent of the populations have occurred in West Texas in 1885, in Galveston in 1897 followed by another in 1922 which centered at Houston, and in South Florida in 1934.

The disease is caused by a virus which circulates in the peripheral blood of the patient from one day before the onset of the disease until the third or fourth day of illness.

The onset is sudden and characterized by a rapid rise in temperature, headache, backache, pain behind the eyes, and sometimes in the limbs. After the first spectacular rise in temperature there is apt to be a cessation followed by another rise after which there is a gradual fall in temperature over a series of days. The average febrile period is about five days but it may be as short as one or as long as ten or eleven days. With the appearance of the second rise in temperature a rash generally appears which when present may vary from a fleeting flushing of the skin to a heavy rash resembling Germa measles and followed by desquamation.

The most important single diagnostic aid is the pronounced leukopenia (decrease in white blood cells) beginning on the second day. This decrease is caused by the loss of both mononuclears and polymorphonuclears, the latter sometimes showing decreases of as high as 90 per cent of normal. Less constant symptoms are the swelling or tenderness of cervical or inguinal lymph glands and painful, swollen joints.

Convalescence is often long and discouraging with attacks of neuralgic pains, mental depression and prolonged weakness. During the attack it is impossible to convince patients by means of statistica evidence on the almost non-existant mortality rate for the disease, that they, at least, are not going to be the exceptions that prove the rule.

When once recognized in epidemic form few cases will escape recognition, but single cases or eve a small epidemic may be missed in the early stages. Diagnoses of malaria, measles, influenza, rheumati fever and even yellow fever have been mistakenly made with considerable justification in the light of the varied phases that the disease may manifest. One old practitioner who had seen lots of dengue in various parts of the world once said facetiously that before a diagnosis of dengue was generally made it was necessary to present the diagnostician with at least 25 cases occurring in the same locality wit in twenty-four hours.

The Rift Valley fever of Kenya Colony and papataci or phlebotomus fever of the Mediterranean, East Africa, India and China resemble dengue in many respects including the leukopenia, but are transmi ted by different vectors and the viruses are immunologically different. Panamanian six-day fever, the seven-day fever of India (not the 7-day leptospirosis) as well as Van der Scheer's five-day fever of Malaya and Bwamba fever of Uganda may be variants of dengue. The absence of susceptible experimental

animals makes it difficult to be definite on these points.

The problem of immunity following an attack of dengue is confused by conflicting reports, many of which undoubtedly originate in cases mistakenly diagnosed as dengue or possibly by a multiplicity of virus strains. Apparently there is a certain amount of immunity which, if constantly rejuvenated by annual attacks which are practically unnoticed, may maintain what appears to be a life-long immunity. On the other hand there is considerable evidence that the immunity from a single attack does not protect a person for much over two years. No successful vaccine has been developed.

The early experimental work on transmission by mosquito vectors has caused considerable confusion in the literature and an undue amount of futile control work. In 1903 Graham announced that he had successfully transmitted dengue by the bites of Culex quinquefasciatus. Later his results were apparently confirmed by Ashburn and Craig (1907) but later developments indicate that Graham had a mixed collection of mosquitoes which apparently contained aegypti and out of Ashburn and Craig's nine volunteers only one was thought to be susceptible and it is not definite that his case (the only positive) was not contracted before the beginning of the experiment. Furthermore the possibility of mechanical transmissions by soiled mouthparts should not be entirely overlooked.

During the middle twenties it became evident that Aedes aegypti and Aedes albopictus were biological carriers. It was shown that these mosquitoes ingest the virus from patients during the period that it is circulating in the blood and after a period of from eight to eleven days, depending on the temperature, their bites become infective for the remainder of the mosquito's life.

In the late twenties and early thirties Simmons and his associates in Manila did an enormous amount of sound work in clearing up many of the puzzling phases of dengue research. Among other things they demonstrated that Macacus monkeys (philippinensis) were susceptible to symptomless attacks by passing the virus from man to monkeys, through other monkeys and back to man. Inasmuch as adult monkeys from endemic areas were immune while those imported from outside were susceptible they assumed that young monkeys might serve as a source of continuing the virus in the absence of human cases.

In addition they reported accurate details of the course of infection in over eighty experimental cases produced with the same strain of the virus which did much to stabilize our understanding of the disease.

Like yellow fever, dengue is forced to maintain itself in areas where continual breeding of its mosquito carriers is possible throughout the year as the virus is not transmissable through the egg to the next generation of mosquitoes. This latter possibility is the accepted procedure in the case of viruses transmitted by ticks or mites. Until, however, some arthropods in this class are found that are capable of transmitting dengue we must program our thinking along the line of mosquito transmission.

Consequently, dengue epidemics will appear in this country only when infected mosquitoes or human cases of the disease are introduced during the season when adult aegypti mosquitoes are prevalent in sufficient numbers to guarantee the perpetuation of the infection.

## YELLOW FEVER

Yellow fever, the dreaded "Yellow Jack" of the tropics, visited continental United States last in 1905, five years after the famous experiments of the U. S. Army Yellow Fever Commission at Havana had demonstrated that Aedes aegypti, then called Stegomyia fasciata, was the vector responsible for spreading the disease from man to man. At New Orleans, the epidemic gave promise from the virulence of the virus of being one of unusual severity. However, for the first time in the history of this country, an epidemic of yellow fever was brought under control before the advent of frost. The measures adopted were screening and larviciding.

The accomplishments of the Army Commission have won for it the well deserved credit of having demonstrated conclusively the mode of transmission of yellow fever and thus paved the way for its control. However, it should be pointed out that the members were "conditioned" for their epoch-making demonstration by a series of events that have been generally overshadowed by the glamour of their accomplishment, the boldness of their procedures and the martyrdom of Dr. Lazear.

Since 1881, Carlos Finlay, a prominent Scotch-French physician of Havana, had been advocating his insistence that Culex mosquito R-D (Aedes aegypti L.) was the vector of yellow fever and had carried on 104 infectivity experiments in which he claimed (by feeding the infected mosquitoes on non-immunes at intervals of only 2-5 days after ingesting infectious blood) to have produced mild cases of yellow fever which conferred immunity.

In 1883 he published in parallel columns the critical points for yellow fever epidemics such as the temperatures at which they decline but may resume, the temperature which permanently arrests an epidemic, the degree of heat that accomplishes the same result and the altitude at which epidemics do not occur. In the opposing column he showed the effects of these same conditions on aegypti, thus producing a circumstantial case against this mosquito that only needed the application of one other bit of information to lay all the ground work for the successful experiments of Reed and his associates on the Army Commission.

This missing link which had frustrated Finlay in the production of frank yellow fever was supplied by Dr. Henry R. Carter of the Public Health Service. In 1898 he had determined what he denominated as the "extrinsic" incubation period of yellow fever as 12 days. This was the smoldering period between the first cases of yellow fever in an epidemic and the appearance of secondary cases. We know now that it is the usual time required for aegypti mosquitoes to become infective after having obtained a meal of infected blood.

Relatively recently Davis has shown that this "extrinsic" incubation period which normally takes 12 days may be reduced to 4 days at 98°F. or extended to 18 days at 70°F. Furthermore, between 50° and 60°F. the progress of infectivity ceases in the mosquito but resumes again at higher temperatures.

Based on the results of the Commission's findings the emphasis for the next quarter of a century was almost solely on control. Gradually yellow fever was being stamped out of South America and equatorial Africa was being considered as possibly the last stronghold of the disease. Then in 1928 Stokes, Bayer and Hudson found that Macacus monkeys could be infected. This spurred on the work of infectivity experiments with scores of other mosquitoes and blood sucking arthropods. This was followed shortly by Sawyer's work in which he perfected a method of infecting white mice and thus made possible the serum-protection test by which the immunity of persons to yellow fever could be tested accurately. This facilitated the testing of populations to determine their previous experience with yellow fever.

The value of these new developments has been amply demonstrated, for without them the newer chapter in yellow fever history could never have been accomplished.

In 1929 at Socorro in the mountains of northeastern Columbia there occurred an epidemic which apparently had no connection with introduced cases and raised suspicions of the possibility of so-called "latent" yellow fever. The next year the small Columbian town of Muzo experienced a similar violent epidemic. Mouse protection tests revealed that yellow fever was actually endemic but the investigators in the area, like several of their predecessors, were forced to come to the conclusion of "yellow fever without aegypti mosquitoes" which had been biological heresy of the rankest sort for thirty years. A blue tree-hole mosquito Haemogogus capricornii was suspected and later experiments justified the suspicions.

Similar sporadics of jungle yellow fever were noted in Brazil and the prevalence of Aedes scopularis and Aedes fluviatilis which Davis and Shannon had shown capable of transmission in 1929 and 1931 were assumed to be the responsible vectors although the former, a semi-domesticated species is not a strong carrier.

In the meantime, of course, the question of warm-blooded hosts of the virus other than man came to the fore. That Macacus monkeys could be infected had been known since 1928 and with this information available and the mouse protection procedure, it was possible to carry on extensive tests with wild animals which did not demonstrate symptoms but which did circulate the virus in their blood, where it might be picked up by susceptible vectors. In addition, the development of immunity was demonstrated in these wild animals by mouse protection tests, thus approaching a means by which surveys to determine the extent of jungle yellow fever might be carried on.

In rapid succession, wild primates, marsupials and rodents were shown to be succeptible carriers in whose blood the virus would circulate for the initial days of the attack and thus serve as a continuing source of infection to the susceptible mosquitoes.

Immediately the picture of yellow fever control took on a sinister and disappointing aspect. With a backlog of infection in the form of jungle yellow fever existing throughout northern South America far beyond the areas inhabited, even sparsely, by whites, the determination and hope of the 20's to eliminate the disease from this hemisphere faded abruptly. Aegypti mosquitoes still remain the great threat for urban populations and unless vigilance is maintained constantly to keep them eliminated from the principal cities of South America and reduced to negligible percentages wherever appreciable numbers of non-immunes are congregated, the chance introduction of a case of jungle yellow fever may produce serious consequences.

Fortunately during all this time, work had been steadily progressing in the strides leading toward a process of human immunization. First, the knowledge that small amounts of convalescent serum would protect against inoculation with the virus; then the production of a fixed neurotropic strain of the virus and finally a combination by Sawyer and Lloyd in 1931 of this fixed strain of the virus with sufficient convalescent serum to protect yet sufficiently potent to cause anti-body formation and protection.

From this point a series of differently cultured strains of the virus were introduced, particularly one that was grown on chick embryos and then mixed with non-immune human serum. The possibility of the departure of large numbers of our troops and sailors to yellow fever territory resulted in the vaccination of literally millions of men with chick-embryo-human serum vaccine. A considerable number of cases of post-vaccinal jaundice led to the substitution of a similar vaccine in which distilled water was substituted for the human serum. The Public Health Service has now liberated over 600,000 doses of the new aqueous base vaccine, each preparation of which is carefully controlled by animal experimentation without encountering any unfavorable reactions.

The production of a safe and relatively inexpensive vaccine comes at a particularly fitting time when we must apparently make up our minds to live with yellow fever, particularly the jungle phase.

We are also particularly grateful for this tool when we consider the added possibility of yellow fever expansion that is possible with the extensive travel by air to the teeming millions of India or the war-impoverished cities of the Mediterranean. There the stage is continually set by the presence of aegypti, a welcoming climate, and millions of non-immunes. It only awaits the entry of the principal villain, the virus itself, either in the body of an infected mosquito or in an unrecognized case.

In continental United States, our chief source of danger is in returning personnel from South American installations that are being constructed for military purposes in hitherto inaccessible points where jungle yellow fever is present.

Our chief strength lies in our awareness of the problem and our preparedness for its possibility. This note is written solely for the purpose of educating and not alarming; for it is as self evident in connection with this problem, as elsewhere in public health, that "what we don't know will not hurt us" is the rankest fallacy.

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The accompanying map of yellow fever distribution by counties in the United States is based on records in the published accounts of yellow fever epidemics. An attempt has been made to eliminate counties whose sole records of the disease were from refugees or travelers from whom no secondary cases resulted. On the other hand some counties have doubtless been omitted because the place names recorded in the older histories could not be located at the time of printing.

COUNTIES WHERE

# YELLOW FEVER

EPIDEMICS HAVE OCCURRED


ATLANTA, GEORGIA

MARCH 1943

# *Aedes aegypti L.*

## VECTOR of DENGUE and YELLOW FEVER

Courtesy Am. Mus. Nat. Hist.